The Oil and Gas Sector in the Brazilian Economy

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Paper Presented at the
16th International Input-Output Conference
2 – 6 July, 2007, Istanbul, Turkey.

ABSTRACT

This paper presents the results of a research conducted to measure the importance of the oil and gas complex in the Brazilian economy and in its states, henceforth called O&G.

Initially, the efforts were concentrated on the construction of an interregional input-output system for the 27 states of the Brazilian economy at the level of 42 industries, for the year of 2002.

By using this system, it was possible to make an analysis of the role played by the oil and gas complex in the Brazilian economy and its states. First it was made an analysis of the economic flows linked to the oil and gas production, and then it is made an estimation of the Gross Domestic Product (GDP) value generated by the oil and gas complex in the Brazilian economy and its states. It was also made a detailed analysis of the productive chain of the oil and gas, starting from the suppliers of inputs to the oil and gas production, going through the production itself and the various stages of refining and processing, and ending at the measuring of the services and distribution activities.

The results show that the oil and gas complex has a share of around 10.4% of the Brazilian GDP, while the share in the GDP of the states ranges from less than 1% to 27%.

1. INTRODUCTION

The productive chain of oil and gas is one of the most complexes in the economy. At the same time, it is an important demander for machinery and equipments industry and the supplier of the most important energy inputs. The chain is also peculiar in several aspects related to its technological profile. Oil is a mineral resource composed by a wide mix of substances. From its processing, several goods are extracted, like gasoline, diesel, kerosene, house gases, fuel and lubricant oil, paraffin wax, and chemical composts. These elements are crucial inputs for several sectors, like ink industry, axes, plastic, oil extraction and vegetal fats, resins, pneumatics, rubber, matches, photo films and fertilizers.

This paper presents the results of a research conducted to measure the importance of the oil and gas complex in the Brazilian economy and in its states. Initially, the efforts were concentrated in the construction of an interregional input-output system for the 27 states of the Brazilian economy at the level of 42 industries, for the year of 2002. Using this system it was possible to make an analysis of the role played by the Oil & Gas Complex in the Brazilian economy and its states. Firstly, it is made an analysis of the economic flows linked with the oil and gas production, and then it is made an estimation of the GDP value generated by the Oil & Gas complex in the Brazilian economy and its states. It is also made an analysis in detail of the productive chain of the oil and gas, starting from the suppliers of inputs to the oil and gas production, going through the production itself and the various stages of refining and processing, and ending at the measuring of the services and distribution activities.

The paper is divided into four sections. Firstly, it is presented an overview on the Brazilian oil chain, considering its characteristics and its recent institutional changes.

The second topic explains how the Oil & Gas Complex GDP was measured, considering the value added to the complex supplier and supplied sectors, and to the extraction and production sector itself. Calculation also includes trading, distribution and services related to the oil and gas products.

General results regarding the interregional system including 42 productive sectors and 27 regions are briefly presented later. The highlight is the GDP estimations associated with the Oil & Gas Complex. A descriptive analysis is placed to size up the importance of the sector to the national and to the regional context. Finally, the conclusions obtained through the analysis are presented.

1.1 Oil and Gas extraction - Historical overview[1]

Brazil has a great potential for oil and natural gas fields, due to its 4 millions square kilometers on onshore sedimentary fields and about one million in offshore areas, gathering 29 basins. Besides, Brazil has a very large territory and the difficulty of access to many regions represents a challenge to the organization of its oil sector.

The birth of the oil industry in Brazil has its milestone in 1938, when President Vargas created the National Petroleum Counsel – CNP. In that decade, the whole consumption of oil was imported, summing up about 38 thousand barrels a day[2]. CNP[3] was an organism directly linked to the Presidency of Brazil and its goal was to set up the long-run guidelines for the development of the Brazilian oil industry, including prices policies, investment priorities and geological studies, supplying and distribution policies, among others.

In the following years, several studies were performed to evaluate the economic potential of the Brazilian sedimentary basins, with the purpose of finding evidence that could justify exploration and production investments, also called E&P or upstream. Initially, efforts have been concentrated on the coast of Bahia, in the Brazilian Northeast, resulting in the discovery of important fields. This region has become the first basin to be explored in Brazil and remained as the most important until the beginning of the 70's.

The second historical landmark in the Brazilian oil industry happened in 1953 with the inauguration of Petrobras – Petróleo Brasileiro (in English, Brazilian Petroleum), a state-owned corporation created to perform activities of research, exploration, development and production of oil and gas in Brazil. In this context, the state monopoly was set up due to the lack of private capital and its unwillingness to undertake such a highly risky activity. There were also political resistances to open the sector to foreign firms. Petrobras, therefore, has become the manager of this monopoly, expanding progressively its activities toward other steps of the productive chain, like processing and distribution. In the middle of the 50's, Petrobras' productive capacity summed up 3,000 barrels a day, which was insufficient to cover the increasing national consumption. This public corporation also undertook oil imports, whose monopoly it granted in 1963. Thereby, the supply of oil for the Brazilian market was

[1] See Dias Leite (1997).
[2] Source: Brazilian Institute of Petroleum.
[3] CNP was suppressed in 1997 and replaced by the National Counsel for Energy Policy – CNPE.

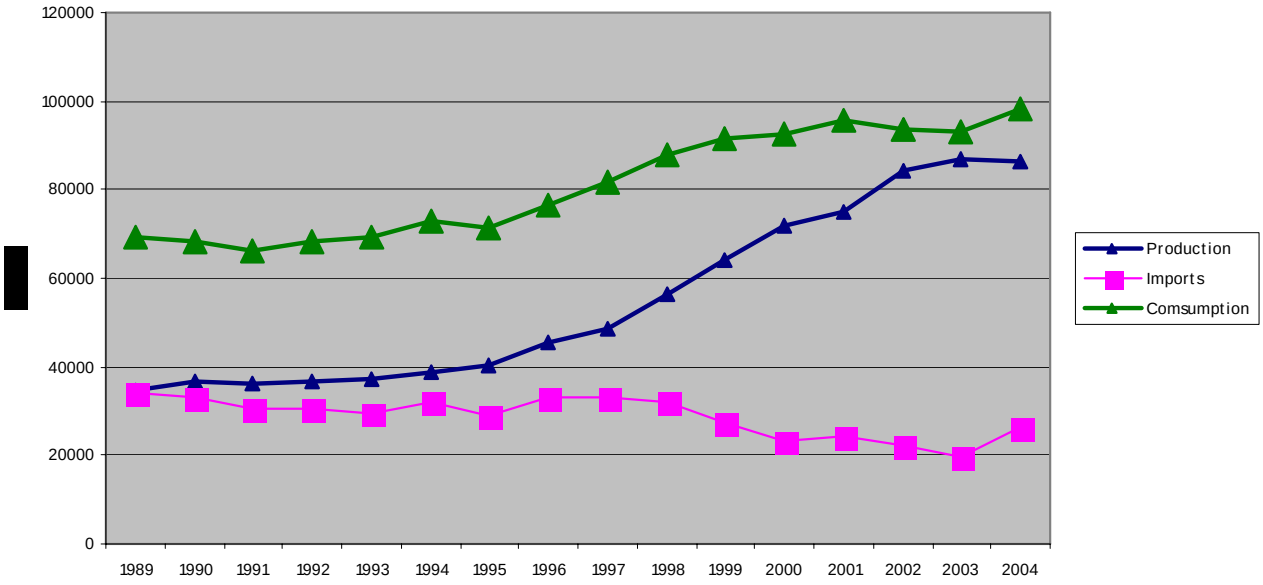
mostly composed by imports. Meanwhile, national production was accounted for less than 15% of national consumption.

The purchases of foreign oil succeeded in complementing the national supply until the beginning of 1970's, when the first oil shock generated a strong deterioration of the Brazilian trade balance. As a result, both the Brazilian government and Petrobras intensified their efforts to reduce the dependence of imported oil, through two main guidelines: enhancing the exploration in other basins and increasing the research of alternative sources of energy, mainly by the so-called Pro-Alcohol, a program that created incentives to the development of alcohol-based cars.

Another front by which the Brazilian government tried to mitigate the problem was the *Risk Contracts*. By this mechanism, a foreign enterprise could get the right to undertake exploratory research in some area. If successful, the firm could extract and sell the resource, paying to the Government royalties of 20% on the value of the output; in the case of failure, the firm should give the area back to the government, assuming alone all the losses with the investment. However, these contracts did not have the desired effect, since only 243 contracts were signed between 1975 and 1988, when the new Constitution vetoed new leases to the private sector. Only one contract (gas) was successful.

In 1974, Petrobras discovered oil in the offshore basin of Campos, in the southeastern state of Rio de Janeiro. Since then, this basin has become the largest Brazilian oil province and the pioneer in deep water exploration. Today, it is responsible for about half of the Brazilian oil production.

In the long run, these efforts were very successful, as we can see in the Graph 1.1. Brazilian oil production has been increasing over time and imports have decreased softly. The production is closer to the domestic consumption and self-sufficiency was reached in April 2006.



Source: Brazilian Ministry of energy

Graph 1.1: Production, Imports and Consumption of Oil in Brazil

Since the middle of the 90's, the Brazilian oil and gas industry has been undergoing deep institutional changes (Vilhena, 1997), mainly in the exploration and production of crude oil and natural gas. With the purpose of attracting the largest possible amount of investment in the sector and to take advantage of the Brazilian basins, the Federal Government has begun to design a new regulation to the oil industry. The core of the changes consisted in allowing the private sector to undertake activities of exploration, development, processing, production and import of oil and natural gas, aiming to break the state monopoly over these activities, enhancing competition and rising the governmental share of the yield generated by natural resources.

In 1995, the Brazilian Congress approved a Constitutional Amendment that extinguished the 40-year-long Petrobras' monopoly in exploration, production and processing of crude oil[4]. This reform was inserted in a broader context, characterized by meaningful changes in mineral policy of developing countries, with the purpose of attracting more investment to these sectors (Otto, 1998). From the middle of the 80's to the middle of the 90's, several Asian, African and Latin American countries have created more favorable laws for the participation of private and foreign capital in their oil and gas sectors. Moreover,

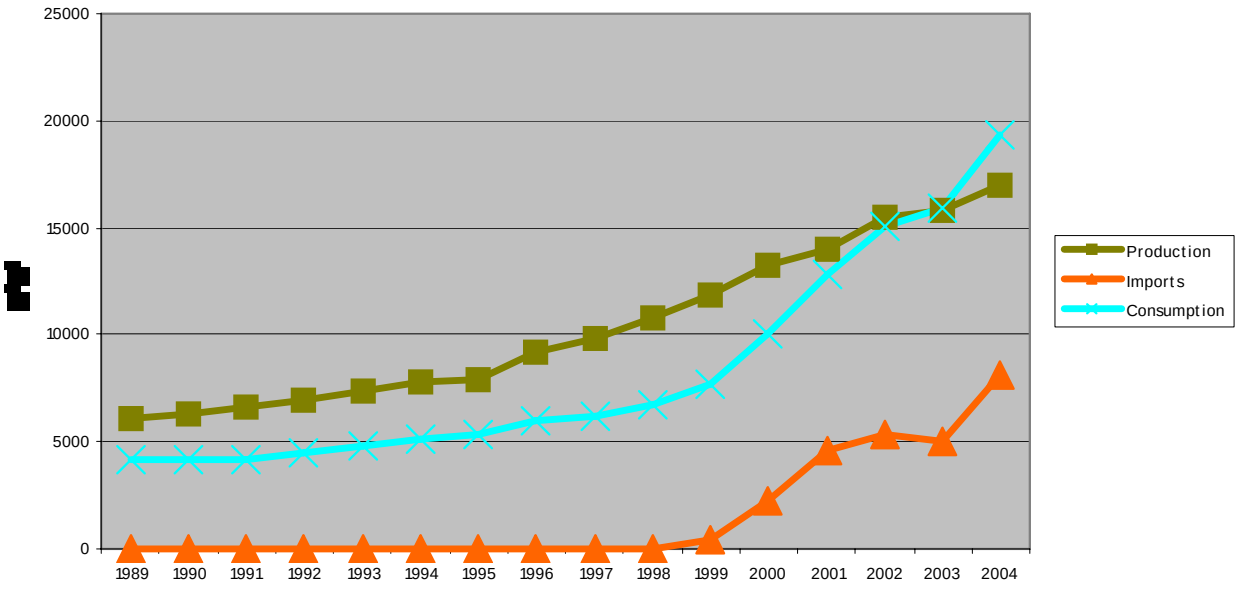
[4] Until then, only the distribution of the oil by-products was allowed to private firms.

during those years, rich countries have raised their investments in less developed countries, as consequence of the absence of homeland opportunities. These new investments were possible due to the new technologies that reduced exploratory costs and enhanced profits of oil corporations. This interaction of international factors and the new regulatory policy rendered attractive to invest in the oil sector in developing countries like Brazil. Summing up, these countries turned their systems from *state monopoly* into a *concessions regime* to private firms.

The reform of the sector can be considered successful, because nowadays dozens of firms conduct exploratory activities onshore and offshore Brazilian basins. Several foreign corporations, like Shell, Texaco and El Paso, also take part in these activities.

It is important to emphasize that these institutional changes were also successful in improving the use of natural gas as energy source. The new law also regulates natural gas. Graph 1.2 illustrates the increasing production, consumption and imports (mostly from Bolivia[5]) in Brazil, mainly after the approval of the Petroleum Law (1997), whose goal is to modernize the energy matrix towards the use of natural gas. In this context, the number of conversions from regular gasoline-based engines to natural gas-based engines cars has grown up at an average rate of 90% from 1996 to 2005[6]. Today, the estimated number of natural gas-based in the Brazilian fleet is above one million[7], and the daily consumption of GNV is[8] about 5.8 millions of m^3.

[5] In May 2006, Bolívia nationalized Petrobras' assets in this country. The future of Brazil-Bolivia relationship concerning gas supplies is still unclear, since the Bolivian Government signalled the desire of reviewing contracts.
[6] Source: Anfavea.
[7] Source: Brazilian Institute of Petroleum.
[8] Source: Brazilian Institute of Petroleum for December 2005.



Source: Brazilian Ministry of energy

Graph 1.2: Consumption, Production and Imports of Natural Gas in Brazil

1.2. Refining and distribution

While the new regulation has been successful in creating competition in exploration and production, the refining is an important shortage in the Brazilian oil industry, since the largest part of Brazil's refineries (11 among 13) belongs to Petrobras. Therefore, despite the liberation of oil-products prices in the Brazilian refineries (which is on since January 2002), Petrobras still has a stunning influence on the price of oil by-products in Brazil and it is able to practice a predatory price policy with the purpose of creating a barrier to entry. Another problem is that most refineries are old fashioned and do not perform well in refining domestic oil, which has a worse quality than the Middle Eastern one, for which the technology of the Brazilian refineries were designed.

Table 1.1 summarizes the share of the oil processed at the Brazilian refineries, according to its origins, from 2002 to 2004. Today, about 90% of the oil processed is domestic and the self-sufficiency is close to be reached[9].

[9] Last April, Petrobras announced self-sufficiency. However, experts believe this situation is fragile and unsustainable, since the economy is showing signals of recovery.

Table 1.1: Origin of oil processed in the Brazilian refineries

Year	2004	2003	2002
Brazil	**75,84%**	**80,20%**	**79,20%**
Campos' Basin	46,02%	64,50%	62,80%
Other offshore basins	21,03%	2,40%	1,40%
Onshore basins	8,79%	13,30%	15,00%
Imports	**24,16%**	**19,80%**	**20,80%**
Middle East	5,73%	6,30%	5,70%
Africa	17,79%	9,90%	12,60%
Central and South America	0,51%	0,70%	2,50%
Australia	0,13%	2,90%	-
Total	**100,00%**	**100,00%**	**100,00%**

Source: Ministry of Mining and Energy

Table 1.2 shows the share (%) of oil by-products produced at national refineries, in equivalent barrels of oil. As one can see, diesel has the biggest share, representing nowadays about 40% of refined oil, since its importance to transportation in Brazil (whose transport structure is mostly road-based). Gasoline, on the other hand, represents 18% of refined oil.

Table 1.2: Composition of processed oil in the Brazilian refineries

In equivalent barrels of oil	2002	2003	2004	2005
Asphalt	2,03%	1,39%	1,64%	0,99%
Coke	1,99%	1,96%	1,80%	2,50%
Gasoline	18,49%	17,45%	16,40%	17,71%
Airplane's gasoline	0,07%	0,07%	0,07%	0,07%
Liquid Oil Gas – GNP[10]	5,95%	6,20%	6,03%	6,65%
Lubricants	0,86%	0,88%	0,75%	0,76%
Naphtha	8,09%	8,27%	7,62%	7,31%
Fuel Oil	19,82%	19,05%	18,91%	17,19%
Diesel	36,47%	37,92%	40,08%	40,24%
Other Non-energy	1,28%	1,49%	1,43%	1,48%
Paraffin	0,15%	0,14%	0,15%	0,13%
Airplane's kerosene	3,76%	3,95%	4,07%	4,03%
Illumination's kerosene	0,24%	0,20%	0,11%	0,06%
Solvents	0,69%	0,78%	0,79%	0,72%
Other Energy	0,14%	0,25%	0,15%	0,16%

Source: ANP

[10] Used for domestic cooking.

The retail supply comprehends two parts strongly connected with each other: the distribution and resale. Both activities have always been allowed to private firms, despite the fact that retail prices were liberalized only in the mid-1990's.

The distribution comprehends the transportation from refineries to the deliverers (gasoline stations) or to domestic consumption (canalized and bottled liquid gas for domestic consumption, called GLP). Nowadays, 276 liquid and gas products deliverers are registered at National Petroleum Agency – ANP.

The resale is considered a public utility activity and is performed by thousands of gas stations spread all over the country. This activity technically comprehends the retail sale of fuels, lubricants and bottled liquid gas. It is necessary authorization from ANP to perform them. Since January 2002, prices are free throughout all the productive chain. There is no longer any kind of price control, maximum or minimum values, or the need of authorization to readjust prices. Thereby, retail prices are a positive function of international prices[11].

Finally, despite the decreasing participation, (see Table 1.3), the Brazilian energy matrix still depends heavily on oil, due to the importance of road transportation for the economy. At the same time, the participation of natural gas has been increasing, reaching 9% in 2004. As it was mentioned before, this is due to the deregulation and the new institutional framework of the Oil & Gas Complex in Brazil.

Table 1.3: Brazilian Energetic Matrix

Type	2000	2001	2002	2003	2004
Nonrenewable Energy	**59.0**	**60.7**	**58.8**	**56.3**	**56.1**
Oil and derivatives	45.5	45.4	43.0	40.1	39.1
Natural Gas	5.4	6.5	7.4	7.7	8.9
Mineral Coal and Derivatives	7.1	6.9	6.5	6.7	6.7
Uranium and Derivatives	0.9	2.0	1.9	1.8	1.5
Renewable Energy	**41.0**	**39.3**	**41.2**	**43.7**	**43.9**
Water and Electricity	15.7	13.6	14.0	14.6	14.4
Wood and Vegetable Coal	12.1	11.6	11.9	12.9	13.2
Sugar's Cane Derivatives	10.9	11.8	12.8	13.4	13.5
Other renewable	2.3	2.4	2.5	2.8	2.7
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Ministry of Mining and Energy

[11] Sometimes, Petrobras was accused of artificially controlling prices with political purposes, as in 2002 Presidential Election.

2. METHODOLOGY TO MEASURE THE OIL & GAS COMPLEX

By assuming the importance of the Oil & Gas Complex in the Brazilian economy, this study measured the total GDP of the productive chain associated to the oil and gas extraction sector through input-output models[12].

The theoretical concept is based on the intensity of both forward and backward linkages that each sector produces in the entire economic system. . Basically, the goal is to consider the oil and gas extraction sector itself as well as the fuel production supplied to other sectors and supplier activities of the oil industry. Thus, the GDP of the Oil and Gas Complex is estimated for its four components: inputs to oil and natural gas exploration and production, the exploration and production sector itself, processing industries and distribution (Figure 2.1).

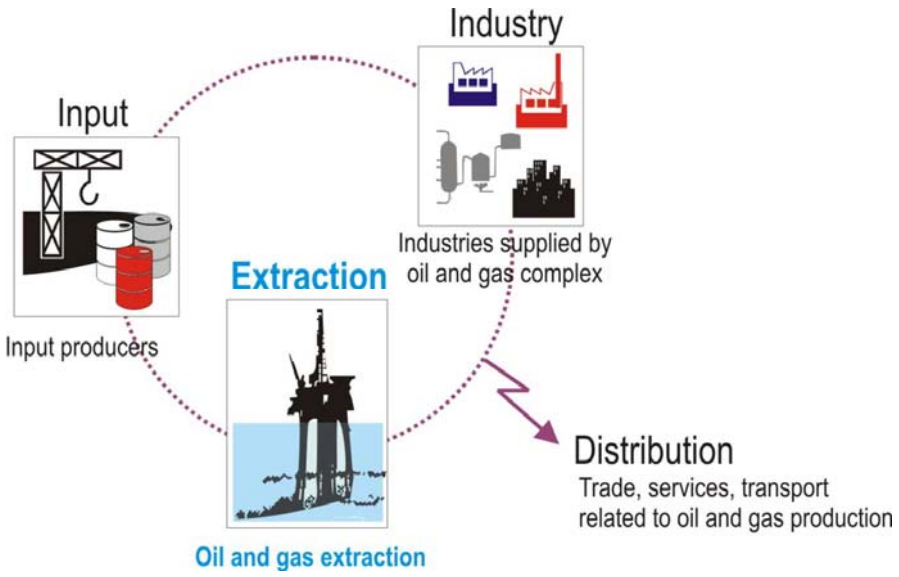


Figure 2.1: The Oil and Gas Complex

[12] The most recent official input-output data released for the Brazilian economy is for 1996 (IBGE, 1996). The present study makes initially use of a national input-output system estimated for 2002 using the methodology developed by Guilhoto and Sesso Filho (2005). The new system was then expanded to an interregional input-output model for 27 Brazilian regions (26 Brazilian states and the Federal District). The process to obtain correct information about the production and consumption of each federation unity was costly and demanded the analysis of many statistical sources. Furthermore, the determination of the interregional flows ran over the use of many algebraic methods as the locational coefficient – Isard (1998), the RAS technique – Miller and Blair (1985) among others. Successive tests were used to evaluate the coherence of the estimations of the interregional and intersectoral flows.

The methodology used is presented below. Further methodological discussions can be found in Furtuoso, Barros and Guilhoto (1998), Guilhoto, Furtuoso, and Barros (2000), and Furtuoso and Guilhoto (2003).

The total GDP value of the Oil & Gas Complex is divided into 4 aggregates: I) inputs; II) the sector itself; III) industrial processing; and IV) distribution, trade and services.

The value added at market prices is given by the sum of the value added at basic prices with indirect net taxes less the financial dummy, resulting in:

$$VA_{MP} = VA_{BP} + INT - FDu \quad (1)$$

where:

VA_{MP} = Value added at market prices

VA_{BP} = Value added at basic prices

INT = Indirect net taxes

FDu = Financial dummy

To estimate the GDP of **Aggregate I** one uses the information available in the input-output tables regarding the input values acquired by the extraction of Oil and Gas sector. The columns with input values are multiplied by the respective coefficient of value added (CVA_i).

The Coefficients of the Value Added for each sector (CVA_i) are obtained by dividing the Value Added at Market Prices (VA_{MP}) of a given sector by its respective output (X_i), i.e.,

$$CVA_i = \frac{VA_{MP}}{X_i} \quad (2)$$

Thus, the metholology allows the elimination of the double-counting issue In that sense the GDP of the **Aggregate I** is given by:

$$GDP_I = \sum_{i=1}^{n} z_{ik} * CVA_i \quad (3)$$

i = 1, 2, ..., n are the economic sectors

where:

GDP_I = GDP of aggregate I (inputs)

z_{ik} = total input value of sector i to the extraction sector k

CVA_i = value added coefficient of sector i

The estimates for the **Aggregate II** (the sector itself - Oil and Gas extraction) considers the value added which was generated by the respective sectors, subtracting the values used as input from the value added of these sectors. Thus the double-counting is again eliminated. Then one has:

$$GDP_{II} = VA_{MP_k} - z_{kk} * CVA_k \qquad (4)$$

where:

GDP_{II} = GDP of aggregate II

and the other variables are defined as previously.

To define the composition of the **Aggregate III** (Oil and Gas based industries) several indicators were adopted such as: a) the main demanding sectors of oil and gas products obtained by input-output matrix estimation; b) the share of Oil and Gas input in the intermediate consumption; and c) the economic activities carrying out the first, second and third transformation of crude oil materials.

In the estimation of **Aggregate III** (Oil and Gas Based Industries) it has been adopted the sum of the value added which was generated by the oil and gas sectors subtracted from the value added in these sectors that have been used as input in the Aggregate II. As previously mentioned, this subtraction is done to eliminate the double-counting in Oil & Gas Complex GDP estimates, so that:

$$GDP_{III} = \sum_q \left(VA_{MP_q} - z_{qk} * CVA_q \right) \qquad (5)$$

where:

GDP_{III} = GDP of aggregate III

and the other variables are defined as previously.

In the case of **Aggregate IV**, regarding the Final Distribution, it has been considered the aggregated value of the Transportation, Commerce and Service sectors. Out of the total value obtained from these sectors only the part corresponding to the share of the products (gas and oil by-products) is designated to the Oil & Gas Complex in the final product demand. The approach adopted in the estimation of the final distribution value of the industry can be represented as:

$$GFD - INT_{FD} - IP_{ED} = DFD \qquad (6)$$

$$VAT_{MP} + VAC_{MP} + VAS_{MP} = TM \quad (7)$$

$$GDP_{IV} = TM * \frac{FD_k + \sum_{q \in k} FD_q}{DFD} \quad (8)$$

where:

GFD = global final demand

INT_{FD} = indirect net taxes paid by the final demand

IP_{FD} = imported products by the final demand

DFD = domestic final demand

VAT_{MP} = value added of the transportation sector at market prices

VAC_{MP} = value added of the commerce sector at market prices

VAS_{MP} = value added of the service sector at market prices

TM = trading margin

FD_k = final demand of extraction sector

FD_q = final demand of the oil and gas based industry sectors

GDP_{IV} = GDP of aggregate IV

The Oil & Gas Complex GDP for each sub-complex is given by the sum of its aggregates as:

$$GDP_{Oil\ and\ Gas} = GDP_I + GDP_{II} + GDP_{III} + GDP_{IV} \quad (9)$$

where:

$GDP_{Oil\ and\ Gas}$ = Oil & Gas Complex GDP

and the other variables are as previously defined.

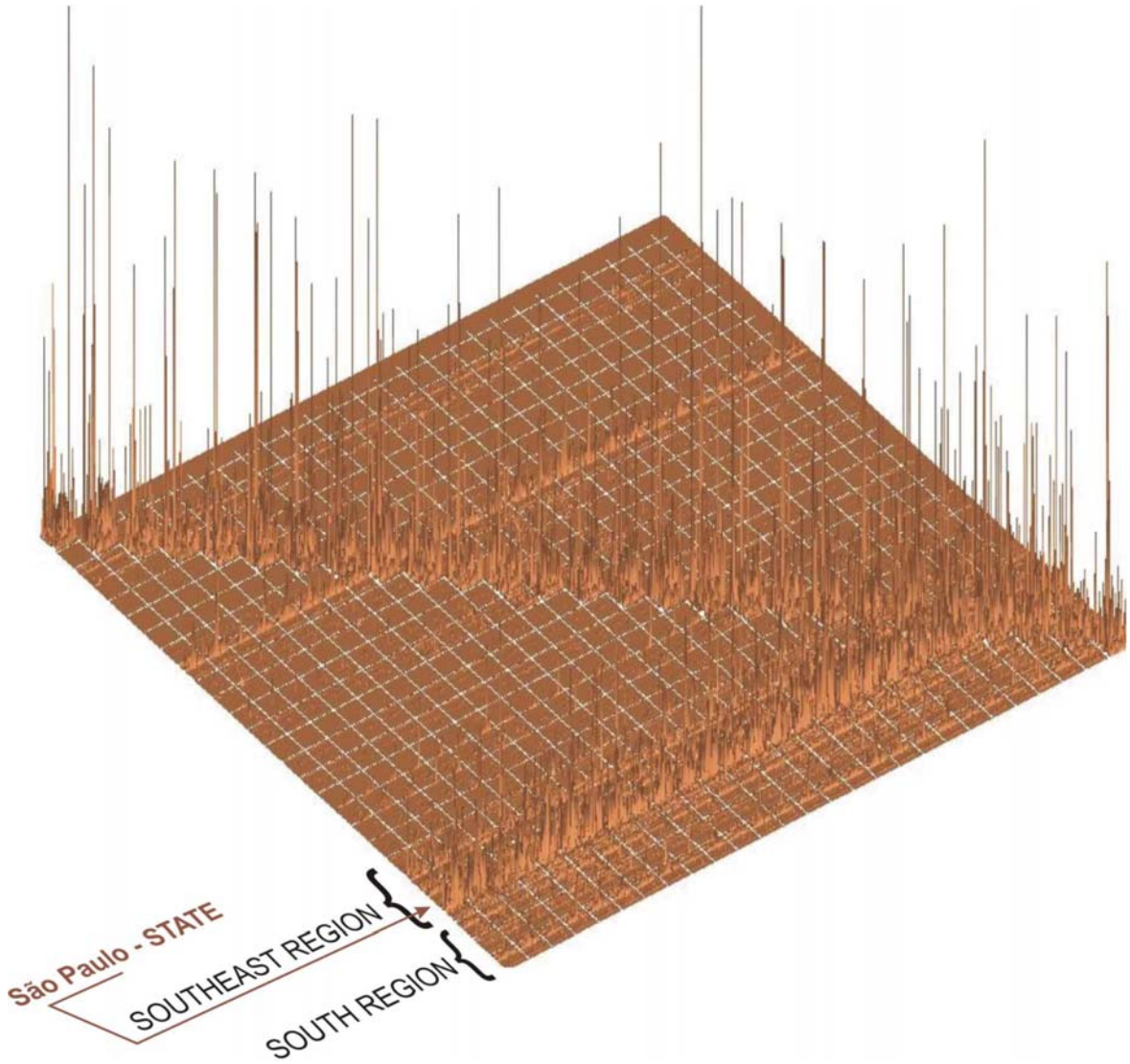
3. RESULTS

3.1 Productive Relations in the Brazilian Economy

Figure 3.1 presents the Leontief inverse matrix estimated for the year of 2002, considering all federative unities of Brazil and its economic activities divided into 42 productive sectors.

To interpret Figure 3.1, we should consider that the larger the technical coefficient the bigger the peak in the three-dimensional space. Each square corresponds to one matrix, sized-up by 42 lines and 42 columns, and each matrix links one region to another. Thus, the figure is formed by 27 matrix lines (27 regions – 26 states and the federal district) linking to 27 matrix

columns (the same 27 regions), composing a square-shaped system of 1134 lines and columns. So the figure of the coefficients matrix is formed by one million and three hundred thousand cells approximately.



Source: Research Data

Figure 3.1. Three-dimensional visualization of the Leontief inverse matrix

The matrices that form the diagonal line in Figure 3.1 represent the technical coefficient of a federal unity within itself. Thus, it is observed that there is a high interaction among the productive sectors in the same state.

Some matrix lines outside the diagonal line also have elevated peaks, they occur in the states that related are mostly to the others. A special importance is noted in the relationship

originated in the state of Sao Paulo and some other states in the Southern and Southeastern regions. Since these states are the most relevant to the system as a whole, they appear elevated in the three-dimensional space, which highlights the strong dependence of other states to these states.

The results for the GDP estimation of the Oil and Gas Complex are presented in the next section.

3.2. Oil & Gas Complex GDP

According to the theoretical bases used in this study, the analysis connected to the Gross Domestic Production (GDP) can be developed in various levels of desegregation due to the fact that the Oil & Gas Complex can be divided into four principal aggregates: a) **inputs** (inputs that are supplied to the extraction sector); b) **the sector itself** (the oil and gas extraction sector); c) **based industry** (industry of oil and gas transformation); and d) **final distribution** (including the commerce, transport and services).

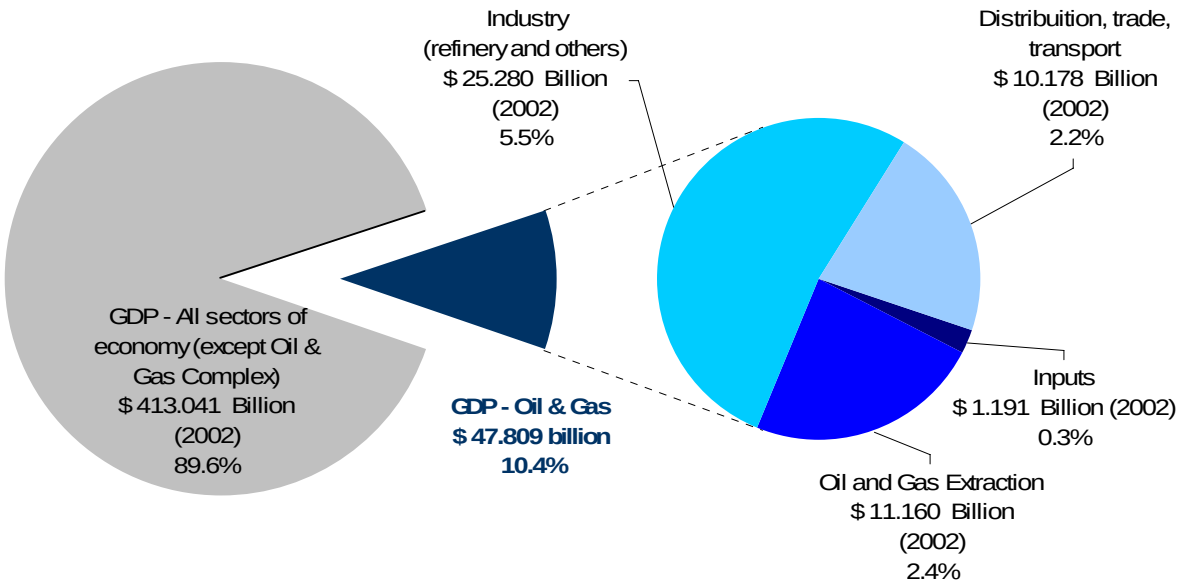
The estimation of each of the four aggregates for Brazil as a whole is also extended to each of the 27 federation unities of the Brazilian economy.

3.2.1. Oil & Gas Complex GDP participation in Brazil

The Graph 3.1 indicates the participation of the Oil & Gas Complex in the Brazilian GDP. The graph also presents the share of the four aggregates used in the calculation of Oil & Gas Complex's GDP.

The Oil & Gas Complex GDP corresponds to approximately 10.4% of the total GDP of Brazil, for the year 2002. From this total, half of it concentrates on the **industry of transformation**, the most important component of the complex. The second most important is the oil and gas **extraction sector itself** with values near to those of **distribution and service**.

The **input** component represents 0,29% of the Brazilian total GDP and 2,5% of the Oil & Gas Complex GDP. It does not include the values related to investments, as for example, all the machinery and equipments necessary to build an oil extraction platform. The component that evaluates the **inputs** (GDP referred to the services performed to the companies, to the industrial utility services, to the manufacture of machines, equipments and replacement metallurgic products, to the maintenance and to the other products considered as input to the oil and gas extraction sector).



Source: Research Data

Graph 3.1. Oil & Gas Complex on the national GDP, billions dollars of 2002.

The **industry of transformation** represents 52.8% of the total complex GDP. It is composed by the industrial group: a) refinery; b) petrochemical and basic oil-chemistry; c) resin, elastomer and filament manufacture; d) pneumatics and rubber industry; e) oil-derived chemical products; and f) plastic industry. These activities are important not only for Oil & Gas Complex, but also for the whole economic system. Consequently, this industrial set is the most influential for the Oil & Gas complex GDP.

The **Oil & Gas extraction** component contains three economic activities: a) crude oil extraction; b) gas extraction; and c) related services. According to the results, the share associated with this component is close to the distribution component, which is composed by trade and transport margins related to Oil and Gas products.

3.2.2. Oil & Gas Complex GDP participation n the federation unities (states)

The Oil & Gas complex GDP in each federation unit can be studied by the use of the interregional input-output system.

Table 3.1 presents the total GDP and the Oil & Gas complex GDP associated to each state and the Federal District (counted in billion of dollars of 2002). The percentual values correspond to the share of the Oil & Gas complex GDP and state total GDP.

Considering the absolute values, the Oil & Gas complex GDP is especially relevant for the Southeastern and the Northeastern states. All together, they respond for 84% of the national Oil and Gas GDP: Rio de Janeiro, Sao Paulo, Bahia, Minas Gerais and Rio Grande do Norte. The share of the South (12.3%) and the production of Amazonas state (Northern region) are also considerable.

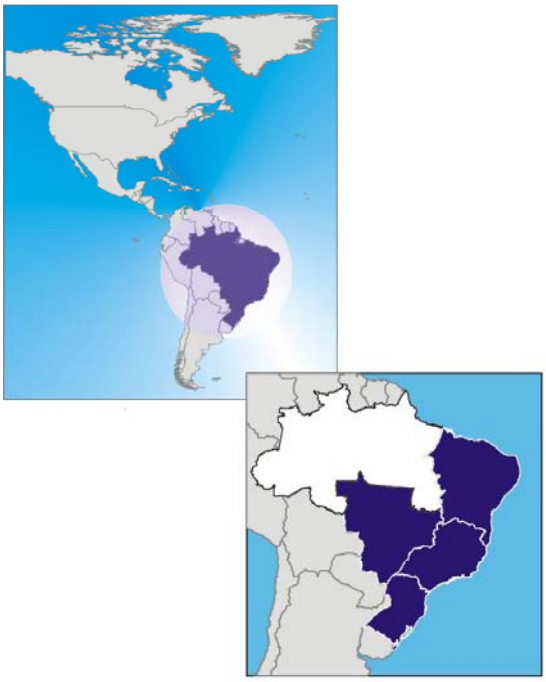
The Oil & Gas Complex share of the total state GDP ranges from 0.8% (Pará) to 26.9% (Rio de Janeiro). The dependence of Rio de Janeiro's economy on the Oil and Gas Complex deserves to be highlighted, due to the Campos basin, located in this state. Bahia and Rio Grande do Norte also have high percentage rates, since they are important producers.

Table 3.1. Total GDP and Oil & Gas Complex GDP in the federation unities.

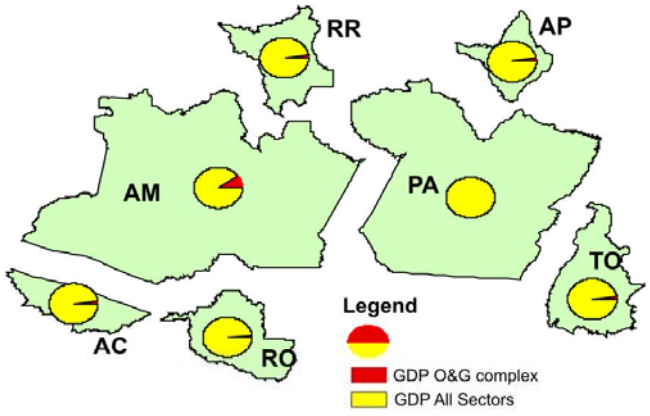
Macro Region	State	State Name	Total GDP ($ Billlion)	Oil & Gas GDP ($ Billion)	Percentage of Oil & Gas in state GDP
North Region	RO	Rondônia	2.463	0.043	1.73%
	AC	Acre	0.756	0.020	2.58%
	AM	Amazonas	9.412	0.999	10.62%
	RR	Roraima	0.486	0.012	2.48%
	PA	Para	8.620	0.069	0.81%
	AP	Amapá	0.900	0.023	2.56%
	TO	Tocantins	1.141	0.029	2.56%
Northeast Region	MA	Maranhão	3.830	0.057	1.49%
	PI	Piauí	2.067	0.039	1.90%
	CE	Ceara	8.111	0.340	4.19%
	RN	Rio Grande do Norte	3.951	0.732	18.53%
	PB	Paraíba	4.093	0.074	1.80%
	PE	Pernambuco	12.169	0.336	2.76%
	AL	Alagoas	2.963	0.223	7.54%
	SE	Sergipe	3.262	0.461	14.14%
	BA	Bahia	20.868	5.113	24.50%
Southeast Region	MG	Minas Gerais	42.884	2.204	5.14%
	ES	Espírito Santo	8.241	0.456	5.53%
	RJ	Rio de Janeiro	57.103	15.374	26.92%
	SP	Sao Paulo	149.712	14.714	9.83%
South Region	PR	Paraná	28.990	1.787	6.16%
	SC	Santa Catariana	18.813	0.795	4.22%
	RS	Rio Grande dos Sul	36.422	3.312	9.09%
Mid-West Region	MS	Mato Grosso do Sul	5.274	0.081	1.54%
	MT	Mato Grosso	5.989	0.129	2.16%
	GO	Goiás	10.582	0.236	2.23%
	FD	Federal District	11.748	0.149	1.27%
Total	Brazil		460.850	47.809	10.37%

Source: Research Data

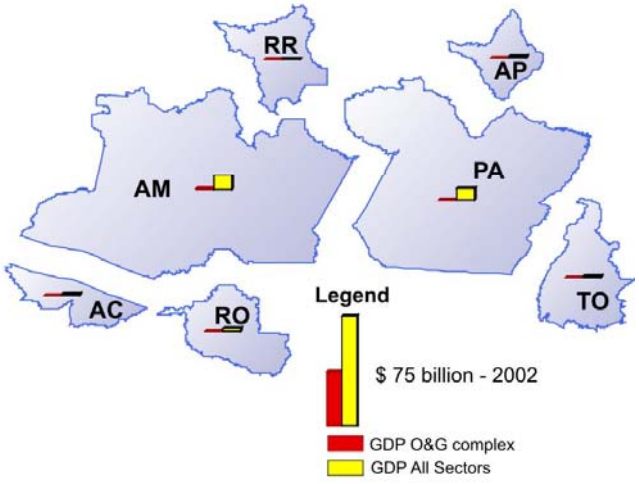
The map below (Figures 3.2 to 3.6) presents the spatial disposition of Oil and Gas Complex GDP related to each state's total GDP, in terms of both value and percentual share, by macro-region.



North Region: localization



Percentage: GDP complex / GDP all sectors

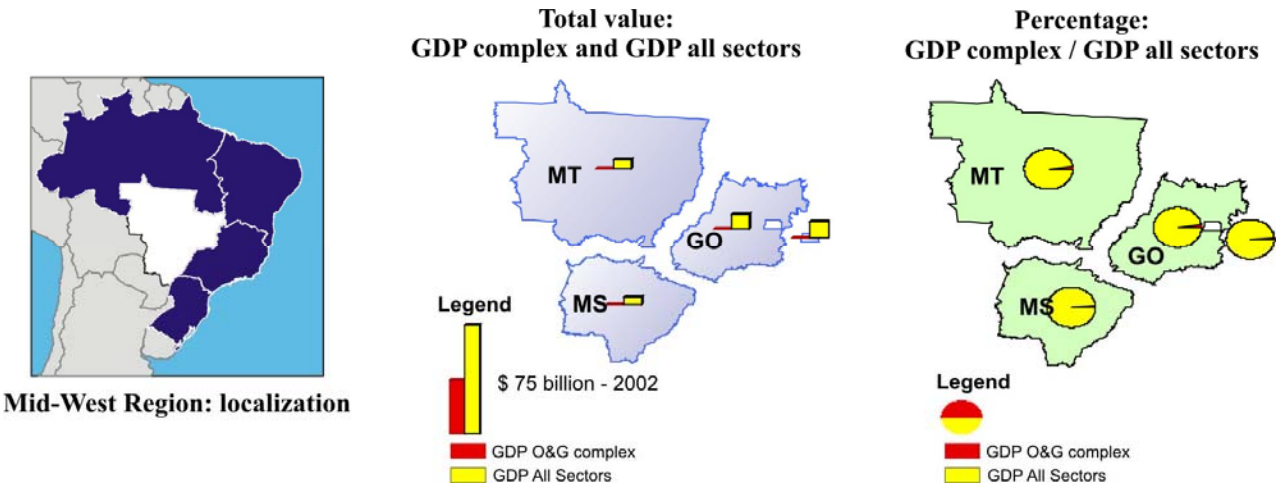


Total value: GDP complex and GDP all sectors

Source: Research Data

Figure 3.2. Total GDP and Oil & Gas Complex GDP for the North region states.

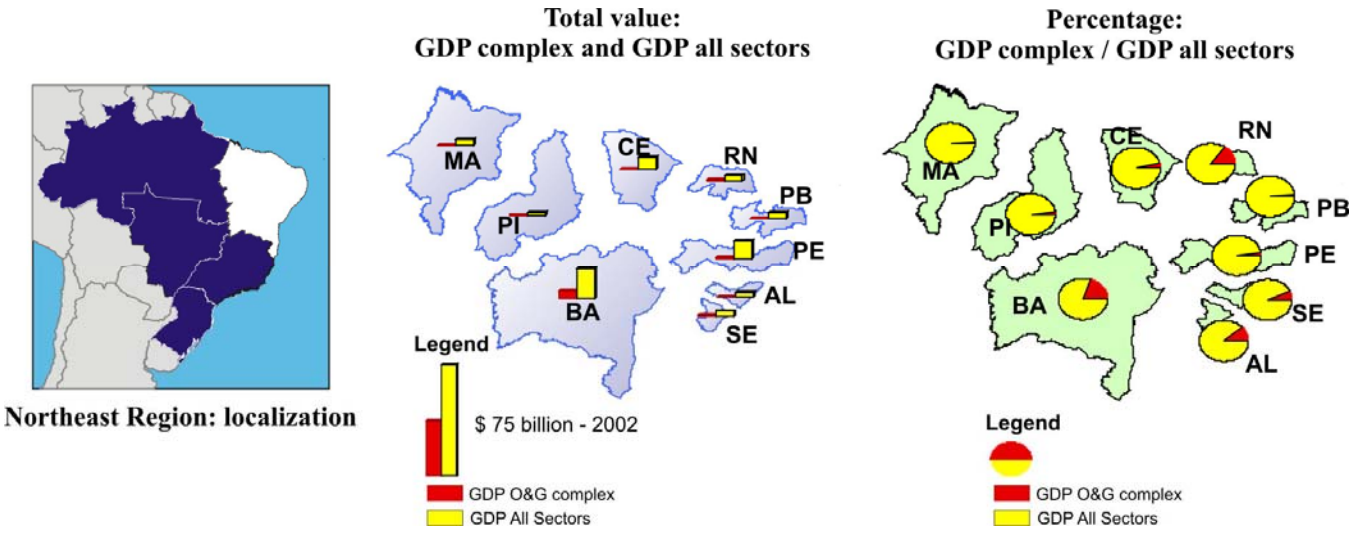
In the North region states the presence of the Oil & Gas Complex is very small. Only in the state of Amazonas (AM) this complex GDP is relevant, representing approximately 10.7% of Amazonas total GDP. It must be kept in mind that there is an oil refinery in Manaus, the capital city of Amazonas.



Source: Research Data

Figure 3.3. Total GDP and Oil & Gas Complex GDP for the Mid-West region states.

In the Mid-West region states, the share of the oil complex GDP is quite under the Brazil's average (10.4%) and the absolute value of production linked to the oil and gas extraction is also low. These states do not have refineries or oil-related industries and they are geographically located far from productive units.

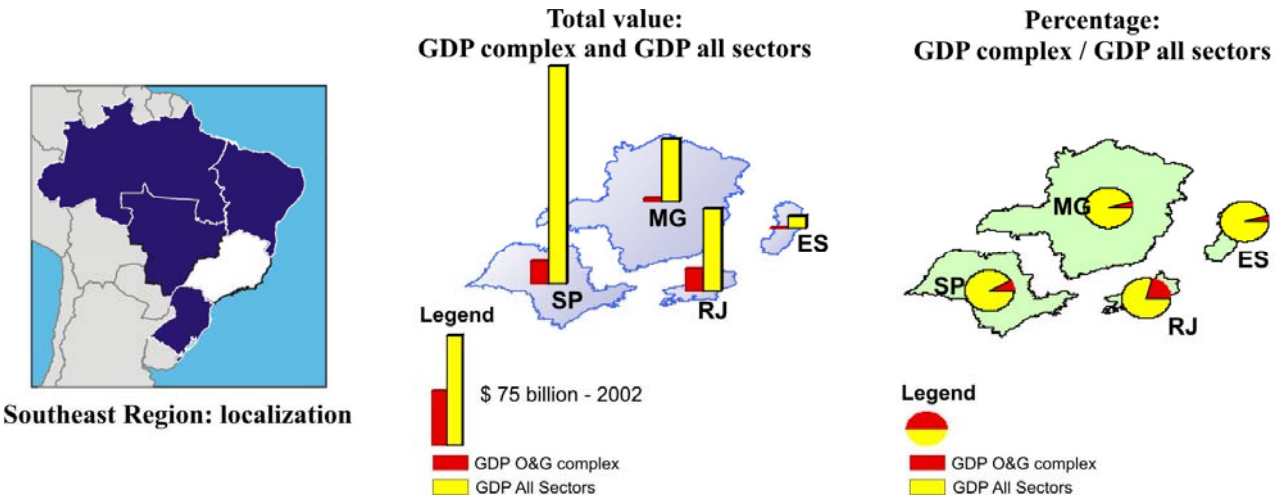


Source: Research Data

Figure 3.4. Total GDP and Oil & Gas Complex GDP for the Northeast region states.

As mentioned before, the Southeast and Northeast regions hold the major part of the Oil & Gas Complex national GDP. In the northeast, three principal states are responsible for

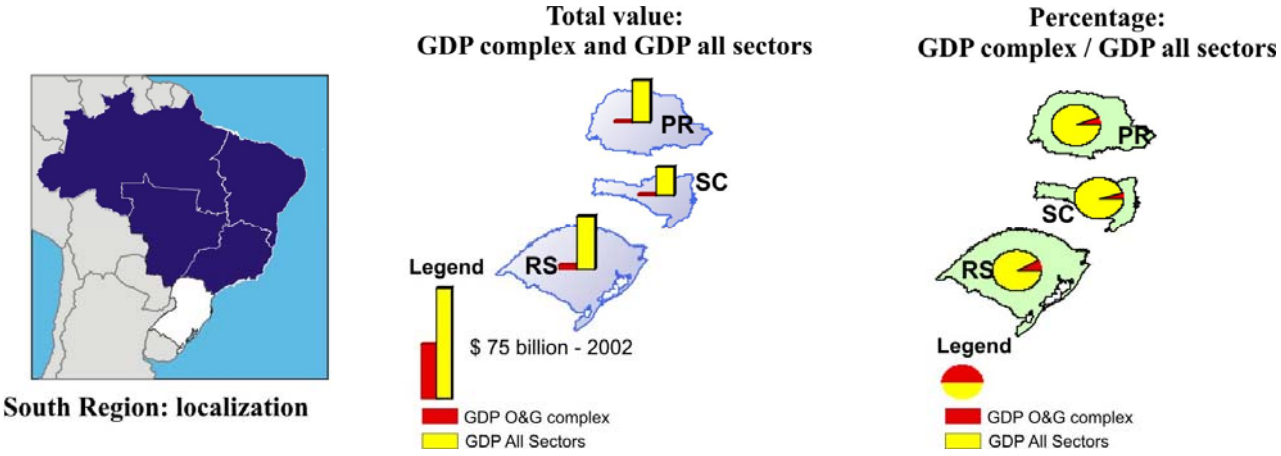
18,4% of the Oil & Gas Complex national GDP. Bahia (BA) alone is responsible for almost 15%.



Source: Research Data

Figure 3.5. Total GDP and Oil & Gas Complex GDP for the Southeast region states.

The Southeastern states, however, account for the majority of the GDP related to the O&G complex, accounting for 86.5% of it. Rio de Janeiro (RJ) and Sao Paulo (SP) are the states responsible for this high proportion, accounting for almost US$ 15.5 billion oil and gas-related GDP in 2002. Rio de Janeiro state takes the lead in terms of absolute values of the O&G complex GDP. Sao Paulo state is not far from it, as it holds an Oil & Gas Complex GDP estimated in US$ 14.7 billion approximately. São Paulo and Rio de Janeiro states are, therefore, the main oil producers, as well as refiners and consumers of oil and gas products.

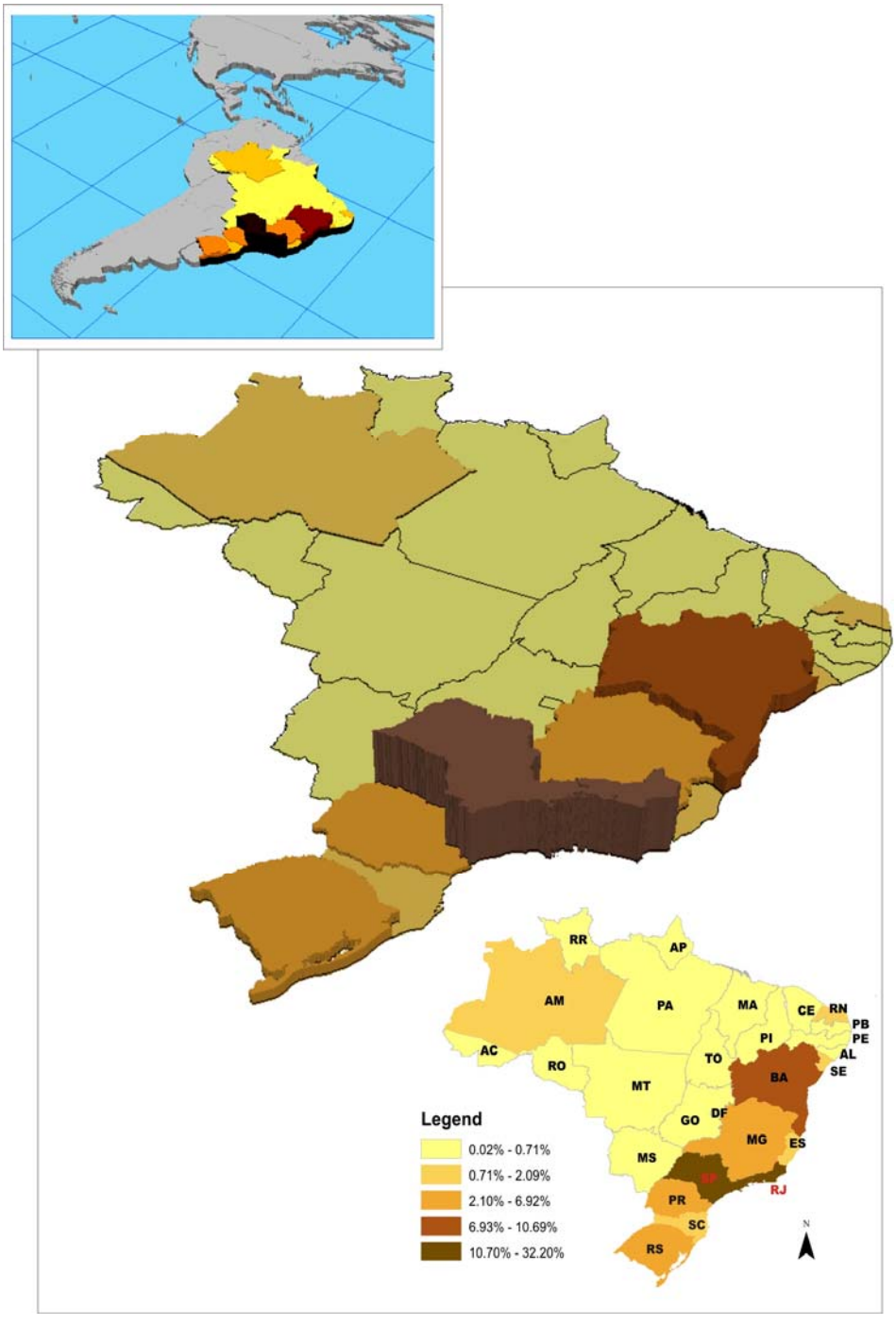


Source: Research Data

Figure 3.6. Total GDP and Oil & Gas Complex GDP for the South region states.

The Southern region states account for 12% of the O&G GDP share, and Rio Grande do Sul (RS) is the most important state among them, followed by Parana (PR) and Santa Catarina (SC). This is due to the fact that Rio Grande do Sul and Parana have processing facilities.

Figure 3.7 illustrates the importance of the Oil and Gas Complex of each state for the national Oil and Gas Complex GDP. Rio de Janeiro and Sao Paulo are the most notable states, followed by Bahia.



Source: Research Data

Figure 3.7. Oil & Gas Complex GDP participation of each state over the national Oil & Gas Complex GDP.

3.2.3. Oil & Gas GDP components share analysis in the states

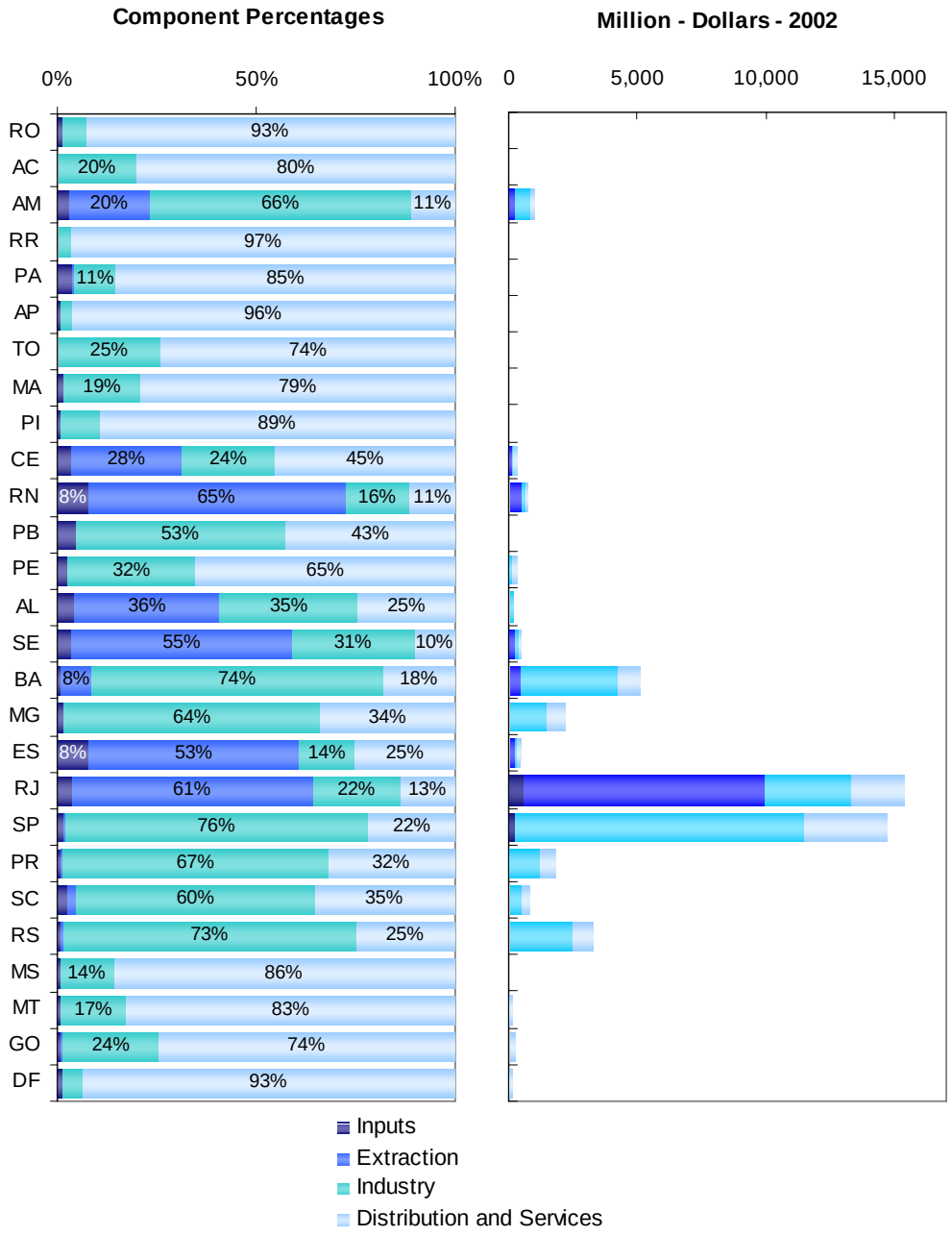
The share of the four components of the Oil & Gas Complex GDP are indicated in Table 3.2 and in Graph 3.2, by each Brazilian state.

Table 3.2. Oil & Gas Complex GDP components in the federation unities

Macro Regions	States	Inputs	Extraction	Industry	Distribution, trade, transport
North Region	RO	0.47	0.00	2.66	39.39
	AC	0.10	0.00	3.83	15.58
	AM	30.82	204.56	656.96	107.11
	RR	0.05	0.00	0.35	11.63
	PA	2.65	0.46	7.30	59.06
	AP	0.21	0.00	0.74	22.10
	TO	0.15	0.03	7.42	21.62
Northeast Region	MA	0.95	0.00	10.99	45.05
	PI	0.39	0.00	3.89	34.97
	CE	11.14	94.86	80.71	153.00
	RN	56.59	474.01	118.16	83.40
	PB	3.37	0.00	38.86	31.42
	PE	8.75	0.14	107.81	219.51
	AL	9.81	81.52	77.35	54.83
	SE	16.95	255.66	142.19	46.62
	BA	48.15	393.86	3,759.08	912.46
Southeast Region	MG	40.36	1.12	1,412.40	750.61
	ES	36.41	240.53	64.67	114.46
	RJ	601.79	9,313.68	3,389.53	2,069.71
	SP	248.78	48.37	11,198.25	3,218.58
South Region	PR	17.30	2.82	1,197.40	569.23
	SC	19.94	16.54	476.87	281.17
	RS	29.50	31.77	2,425.11	825.24
Mid-West Region	MS	0.62	0.06	10.99	69.52
	MT	0.99	0.00	21.57	106.67
	GO	2.32	0.51	57.84	175.83
Federal District	FD	2.08	0.00	7.83	139.45
Total	Brazil	1,191	11,161	25,281	10,178

Source: Research Data

Graph 3.2 is made up of by two parts: the horizontal bars on the left side show the share of the four components (input, extraction, industry of transformation and distribution) on each state Oil & Gas Complex composition. The bars on the right side indicate the contribution of each part, in 2002 billion dollars. The Graph 3.2 provides a better visualization of the data from Table 3.2.



Source: Research Data

Graph 3.2. Share and values of Oil & Gas Complex components in the federal unities.

The **input** component contributes with a reduced share (2.5% - Graph 3.1), showing a low relevance for the GDP's composition in all states (from 0.45 to 7.98%).

Concentrated in few productive states, the component **extraction** sector was responsible for 23.3% (Graph 3.1) of the Oil & Gas Complex GDP in Brazil as a whole. Only 6 states (RJ, RN, BA, SE, ES e AM) account for 97.5% of the oil extraction-related GDP. Rio de Janeiro has to be noted for accounting for 83% of all national GDP related to the oil and gas exploration and production sector.

As for the chain structure of the Oil & Gas Complex, the component **industry** of transformation accounted for with 52.9% (Graph 3.1) of the national value. Its importance is related to the presence of large refineries in seven states (SP, BA, RJ, RS, MG, PR e AM), which embrace basically the totality of the large refineries in the country. Those states account for 95% of industry of transformation GDP. Sao Paulo alone account for 44.3%, and it is the most important state for the petroleum and gas transformation process, due to the 4 refineries located in its territory.

The component **distribution** and trade accounts for 21.3% of the Oil and Gas Complex GDP. In states with no oil extraction or transformation, the share of the component distribution in the state is high. In Roraima (RO), for example, this component accounts for 96.7% of the state O&G GDP.

4- CONCLUSIONS

The method that determines the GDP calculation assumes four components: the input supplying, the Oil and Gas extraction sector, the industry of transformation and the sectors of distribution and trade providers. In this case, the sector studied is the Oil extraction and the GDP is calculated based on the inter-sector enchained data determined by the matrix flows. It includes other sectors' products this sector consumes and the goods this sector supplies to the other sectors.

As the main result, it was found that the Oil & Gas Complex GDP corresponds to approximately 10.4% of the Brazilian total GDP in the year of 2002. From this total, more than a half (5.5%) refers to the on industry of transformation, which makes this component the most important of the complex. The second most important is the Oil and Gas extraction sector accounting for 2.4% of the total national GDP. This component includes all the petroleum and gas extraction and the services provided in the oil-well and natural gas-well. Its importance for the GDP is closed to the distribution component (2.2%) formed by services, trade margin and the transportation associated to the Oil and Gas products.

By considering the five macro-regions, the Oil & Gas Complex GDP is especially relevant in the Southeastern and in the Northeastern, which jointly account for 84% of the Brazilian O&G complex production value. Some states have to be emphasized in this order: Rio de Janeiro, Sao Paulo, Bahia, Minas Gerais and Rio Grande do Norte. The participation of Southern states and the state of Amazonas has also to be considered.

Regarding to the states, the Oil & Gas Complex share in the states total GDP is between 0.8% (Para) and 27% (Rio de Janeiro). The oil and gas complex is particularly important for Rio de Janeiro, where more than a quarter of the total state GDP depends on the complex. The complex influence over state GDP is also present in other states like Bahia and Rio Grande do Norte, as cited before

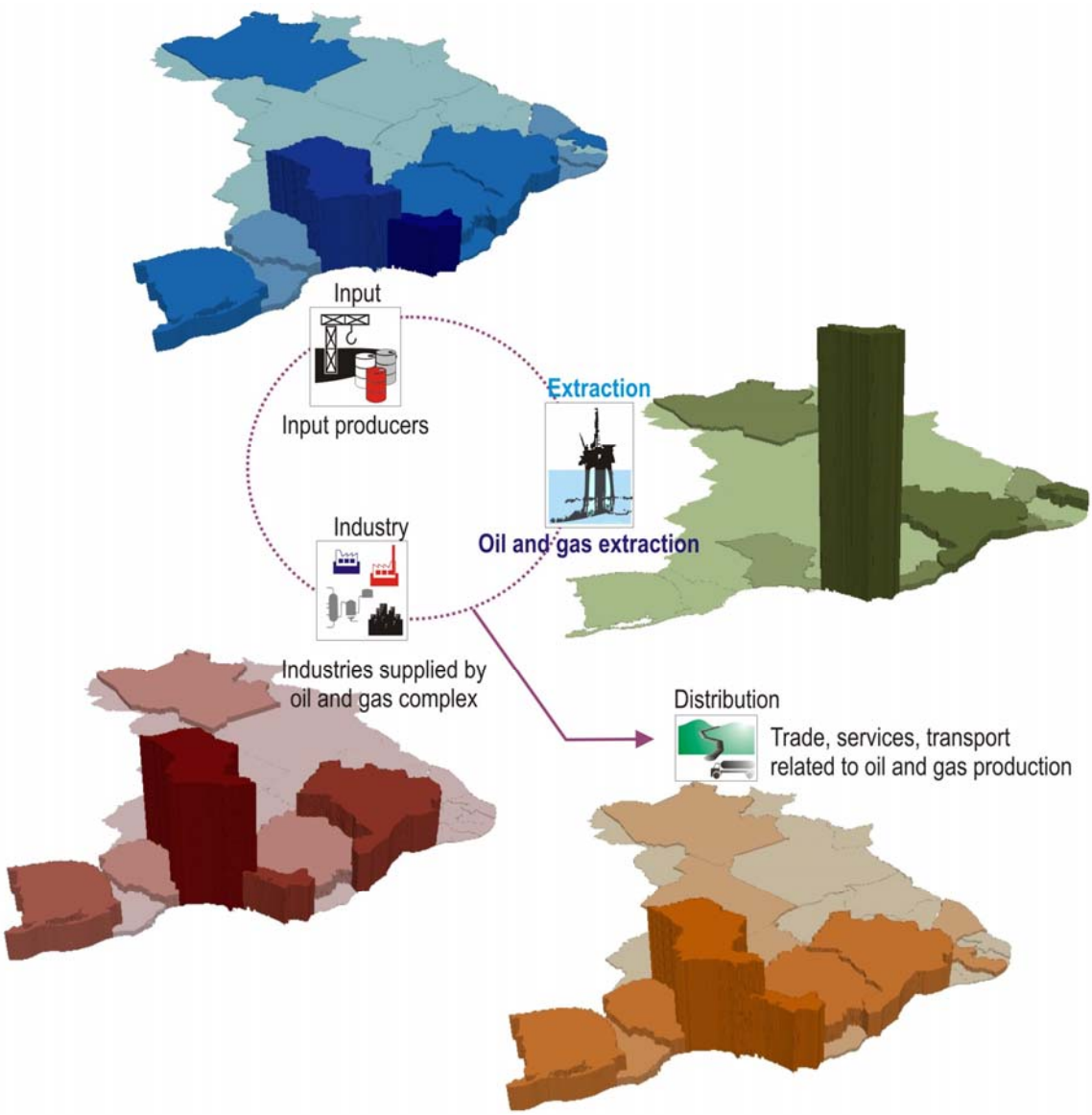
Observing the federation unities share on the O&G Complex GDP composition and each of its components (input, extraction, transformation and distribution), it was noted in Figure 4.1 that Sao Paulo state is the most influential in three of the components (input, transformation and distribution). However, its difference of weight compared to the other states is not as significant as when its weight is compared to Rio de Janeiro due to the extraction component. It was evident that the extraction sector GDP is predominant in Rio de Janeiro since the extraction is concentrated offshore this state (one single exception is demonstrated by the Amazonas state).

São Paulo is noted by its set of the industry of transformation, with four refineries and one petrochemical pole. This state also has industries directly associated to the petroleum products, such as the chemical and rubber industries. Observing the map regarding the industrial component, in Bahia, its importance is attributed to the Camaçari petrochemical pole. In other states such as Rio Grande do Sul and Minas Gerais, the refineries, petrochemical and resin industries are important to the GDP state composition.

It follows that the Oil & Gas Complex assumes great importance in the Brazilian economy, representing a tenth part of the national total GDP. Almost half of this percentage is attributed to the transformation sector, indicating that the industry sector associated to this complex is quite well developed. Thus, besides the ability of extracting petroleum and gas from its reserves, the country is also capable of effectuating the subsequent process of the productive chain, adding value to the products which are, mostly, consumed inside the country. With new petroleum basin discoveries and the increase of the volume of petroleum extracted, Brazil has become independent in terms of non-renewable energy sources and its by-products. Nevertheless, the refining sector is still concentrated and unable to process all the crude oil extracted from Brazilian basins.

Obviously, it contributes to the country’s economic development, but the spatial distribution of this complex is not homogeneous. The largest petroleum reserves are located offshore, leading the country as a reference in the technology of petroleum extraction in deep waters. It justifies the petrochemical industry installation in the coast neighborhood and the

insignificant presence of the Oil & Gas Complex in states in the countryside, with one exception, the state of Amazonas, where oil and gas reserves and gas-well were found.



Source: Research data

Figura 4.1. Magnitude of state components GDP from Oil & Gas Complex

The country´s self-sufficiency in oil and gas is strategically important to the national development since it guarantees the energy supply necessary to the industrial growth and provides one of the most important primary goods, useful for to the production of a variety of products. The presence, inside Brazil, of most of the technology used in this production chain, contributes to the generation of value added, inside the country. These funds are responsible for researches and new technologies creation related to the non-renewable and also renewable combustible production. The alcohol and bio-diesel are real promises that could replace part

of the non-renewable combustible demand, supporting cultivation such as sugar-cane, soybean and castor bean placed in the countryside.

Last but no least, the resources acquired in the Oil & Gas Complex finance the Oil & Gas technologies and, in the future, they might help consolidate the use of renewable fuels, improving the wealth geographic distribution, towards the countryside of Brazil, through an increase in the agricultural products demand.

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